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Field monitoring at spill sites usually involves collection and analysis of ground water, soil gas, and/or core material. Applications for soil gas are limited to volatile contaminants in the vadose zone. Groundwater assays are useful, but detect only contaminants associated with the aqueous phase. Total contamination of the subsurface, especially for petroleum hydrocarbons, is best measured by vertical profile core sampling and analyses. Our field site characterization studies of fuel spills involve vertical profile core sampling for direct analysis of combustible gas and solvent extractions for total petroleum hydrocarbons by infrared spectrometry or aromatic hydrocarbons by gas chromatography.

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APPLICATION OF LASER INDUCED FLUORESCENCE IMPLEMENTED THROUGH A CONE PENETROMETER TO MAP THE DISTRIBUTION OF AN OIL SPILL IN THE SUBSURFACE

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INTRODUCTION

Field monitoring at spill sites usually involves collection and analysis of ground water, soil gas, and/or core material. Applications for soil gas are limited to volatile contaminants in the vadose zone. Ground water assays are useful, but detect only contaminants associated with the aqueous phase. Total contamination of the subsurface, especially for petroleum hydrocarbons, is best measured by vertical profile core sampling and analyses. Our field site characterization studies of fuel spills involve vertical profile core sampling for direct analysis of combustible gas and solvent extractions for total petroleum hydrocarbons by infrared spectrometry or aromatic hydrocarbons by gas chromatography.

OBJECTIVE

The objective of the study was to demonstrate the usefulness of a laser induced fluorescence cone penetrometer (LIF-CPT) as an inexpensive and rapid alternative to taking core samples for defining the three-dimensional boundaries of an oily phase plume.

OPERATIVE COMPONENTS

(Armstrong Laboratory's Environics Directorate)

Dakota Technologies, Inc. and Applied Research Associates, Inc., under contract with the U.S. Air Force, have developed a LIF-CPT tool for mapping the distribution of petroleum hydrocarbons as NAPL's (nonaqueous phase liquids). Principal individuals from the two organizations involved in development and application of the specific LIF-CPT probe used in this study are Wesley L. Bratton, Randy St.Germain, Martin L. Gildea, Greg D. Gillispie, and James O. Shinn. Basic operating components are an optical system to ~~emit~~ deliver tunable laser radiation into an optical fiber for transfer downward through a cone penetrometer to a sensor tip equipped with a sapphire window. The subsurface material next to the window fluoresces. This fluorescence radiation is transmitted back to the surface where intensity, fluorescent lifetime and wavelength are measured.

The CPT fluorometer was tuned for condensed ring aromatic hydrocarbons which are

naphthalene class

were

common constituents of petroleum products. Acquired data was stored on a floppy disk for later processing. Data plots were also displayed on a monitor screen for direct interpretation as the probe moved downward. The CPT unit was also used for continuous profiling of soil stratigraphy and collection of soil gas, ground water, or core samples.

FIELD SITE

The field study site was used extensively as a fire-fighting training area from 1950 to the mid-1980's. Fire training pits were flooded with water, and waste jet fuel mixed with oil and solvents was floated on the water and ignited. Then the burning oil was extinguished. Any unburned oil infiltrated ~~with water~~ after these exercises. Pits were constructed in about 70 feet of sand above a confining layer of clay. The water table is about 30 feet below the ground surface. The ground water seepage velocity is about 0.4 feet per day.

RESULTS

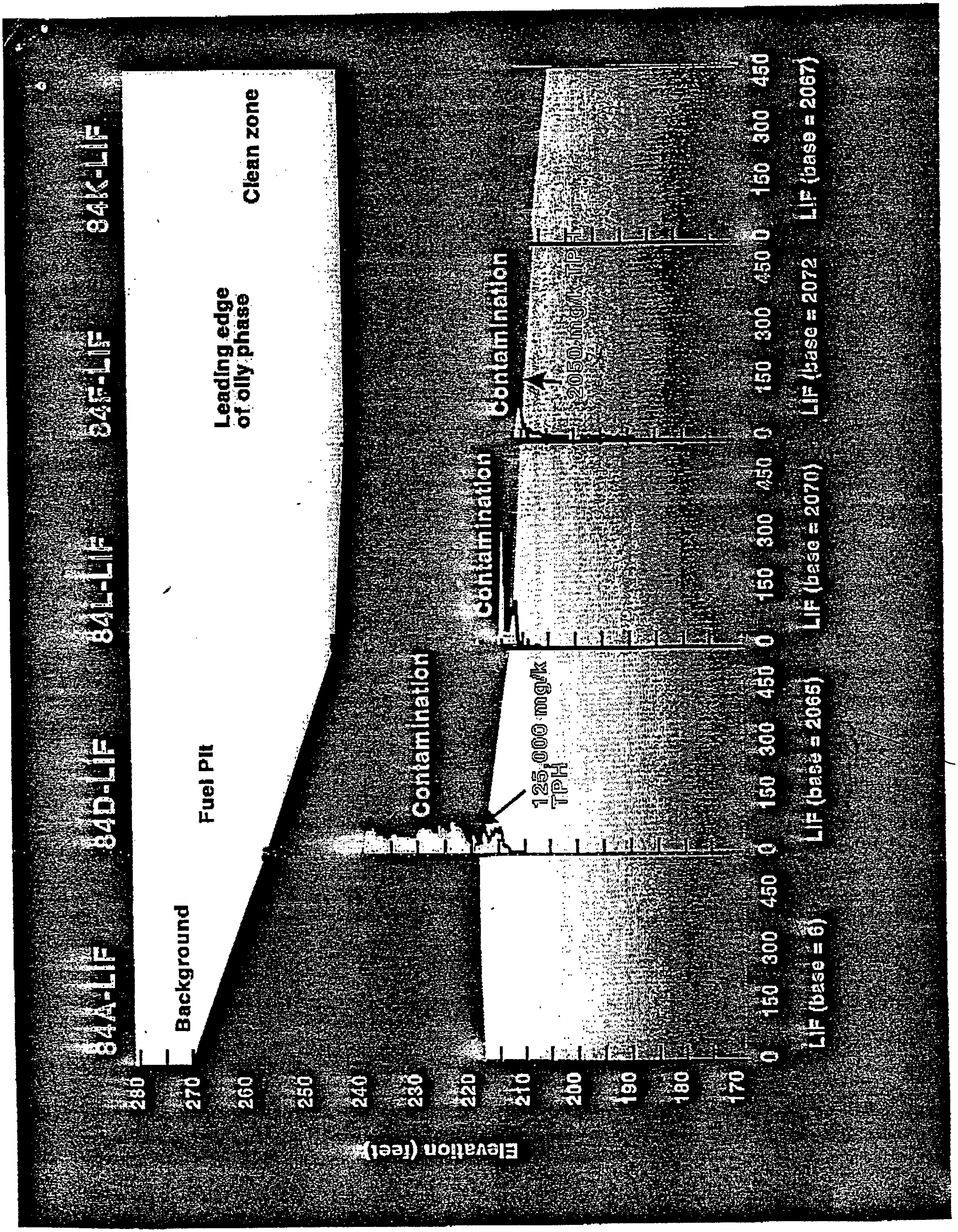
Vertical profile LIF-CPT probe responses were obtained at nine locations at the study site. Figure 1 shows probe responses in a longitudinal transect through the fire training area parallel to the direction of ground water flow. Strip chart displays for each location depict relative fluorescence measurements. Location 84D was within the fire pit. Beginning at 15 feet below the land surface, a LIF-CPT response positive for oily phase was obtained. This response extended another 30 feet downward to a position 5 feet below the water table. A core taken at the water table contained 125,000 milligrams total petroleum hydrocarbons (TPH) per kilogram soil. From combined LIF-CPT and TPH information, it is estimated that 85 per cent of the oily phase is present above the water table. Remediation by vadose zone venting would remove a major portion of subsurface contamination.

Test locations 84L and 84F were 100 feet apart and 700 feet downgradient from the fire pit (Figure 1). Oily phase product was present in the capillary fringe ~~at the water table~~ at both locations. Core material collected at the water table depth at location 84F contained 2,050 mg TPH per kilogram soil. Location 84K, located 100 feet downgradient from 84F, did not have a positive response to LIF-CPT probing. The leading edge of the oily phase plume was ~~identified~~ less than 100 feet beyond 84F.

Figure 2 is a display of the TPH and LIF-CPT results for location 84D and shows a direct relationship for the two parameters. Other information will be presented to show that results obtained for specific fuel aromatic hydrocarbons also show a direct relationship with TPH and LIF-CPT results.

DISCUSSION

The laser induced fluorescence test probe used as an on-site rapid assay tool performed successfully to map, in three dimensions, the oily phase plume studied. Applications of the LIF-CPT technology will be utilized ~~in the future~~ at other field spill sites. We are continuing system development to apply the LIF-CPT method to characterization studies at sites differing in the classes of hydrocarbons present.



2" = 20ft

FIGURE 1.

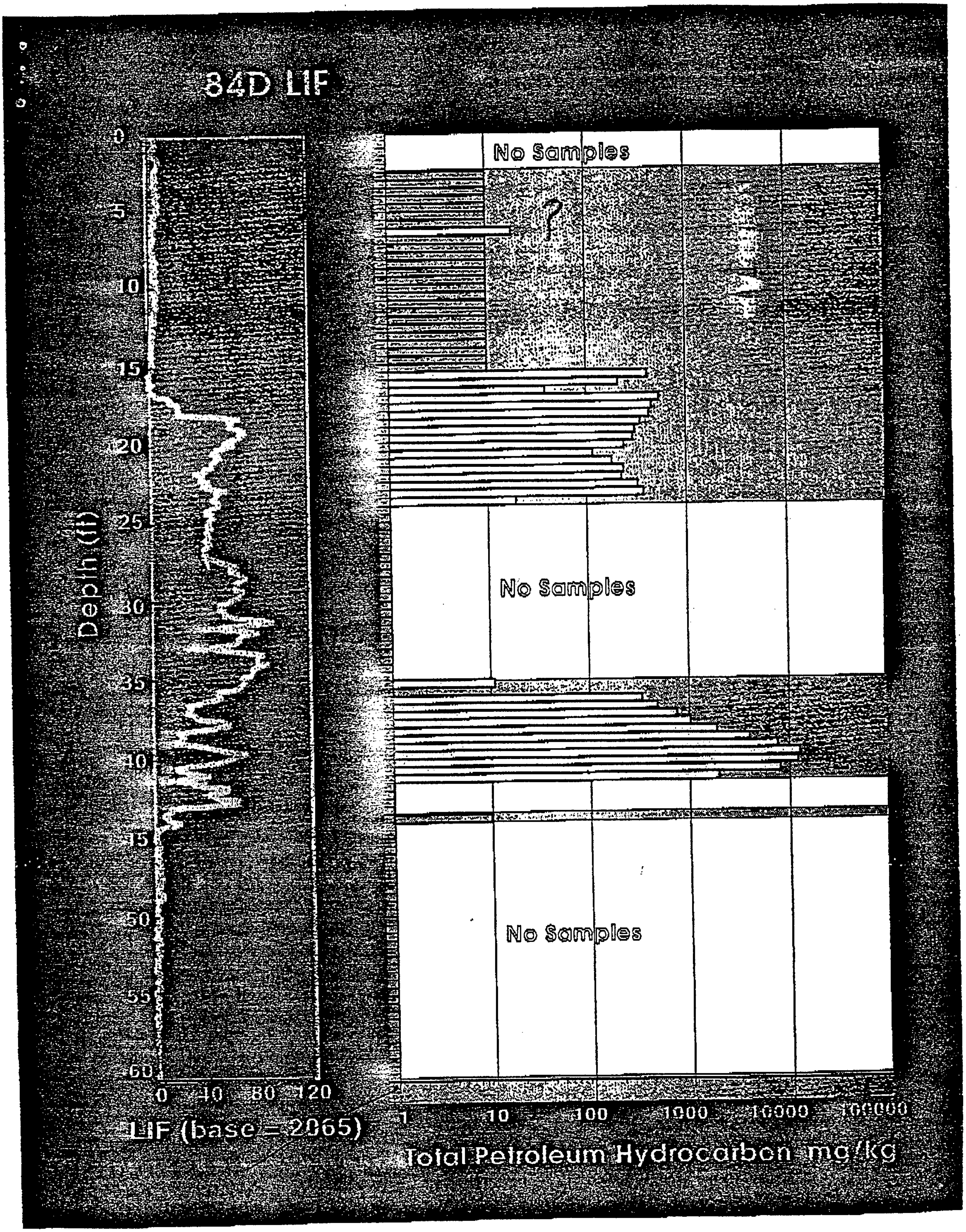

84D LIF
Depth (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
0 40 80 120
LIF (base = 2065)
No Samples
?
No Samples
No Samples
1 10 100 1000 10000 100000
Total Petroleum Hydrocarbon mg/kg

FIGURE 2.